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Project Report

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YELLOWHEADED SPRUCE SAWFLY: SOME FACTORS AFFECTING INFESTATION AND DEFOLIATION OF WHITE SPRUCE

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Yellowheaded Spruce Sawfly: Some Factors Affecting Infestation and Defoliation of White Spruce

INTRODUCTION

The yellowheaded spruce sawfly, Pikonema alaskensis (Rohwer), occurs in outbreak populations in young open-growing plantations and natural stands of white spruce. The outbreaks cause substantial height growth loss in young trees and, occasionally, mortality. Infestations have been observed to be of localized distribution within plantations. Pockets of light or no defoliation occur immediately adjacent to pockets of severe defoliation. These pockets appear consistently in the same location each year for the duration of the outbreak.

This cooperative project was conducted by the Department of Entomology, Fisheries and Wildlife, University of Minnesota, and the USDA Forest Service, Northeastern Area, Forest Insect and Disease Management, St. Paul Field Office. The Blandin Paper Company allowed the use of their white spruce plantations for the field work.

OBJECTIVE

The purpose of the project was to identify selected physical and chemical characteristics of white spruce and selected soil characteristics for their effect on infestation pattern and severity. The information could provide guidelines to evaluate white spruce plant sites to avoid damage from the yellowheaded spruce sawfly.

METHODS

A. Location and Design

Infested areas were selected in the vicinity of Grand Rapids, MN. Three white spruce plantations were established as study blocks. Each block was divided to provide three plots of three levels of previous defoliation: light (6-19%), medium (20-49%) and heavy (50-100%). Within each of the 27 plots, nine sample trees were randomly selected for measurements of physical and phenological data.

Soil samples were collected under each sample tree and along transects between plots within each plantation.

B. Tree Measurements

1. Effect of Defoliation

Measurements of total height were taken as well as the length of the terminal growth. For each tree the percent of the final defoliation was recorded at the end of the larval feeding period. These data were analyzed to express growth expectation in terms of leader growth and percent defoliation.

2. Buds

Dates of bud flush and development were recorded through loss of the bud scales. The bud volume was measured and the number of eggs deposited in new foliage recorded to determine any relationship with infestation levels.

3. Foliage Growth

The development of needle distention from the critical axis of the bud was recorded by ocular measurement of the angle of the needle to the shoot.

4. Foliage Nutrients

Forty pairs of trees were selected from four plantations. One of each pair represented low (0-10%) defoliation, the other high (75%) defoliation levels. The trees in each pair were chosen close together to reduce soil and site differences. Newly emerged foliage was collected and stored in plastic bags on dry ice until laboratory analysis was completed. The foliage was analyzed for nitrogen (N), using the semimicro Kjeldahl Method, and also for phosphorus (P), potassium (k), calcium (Ca), Aluminum (Al), sodium (Na), iron (Fe), magnesium (Mg), zinc (Zn), copper (Cu), molybdenum (Mo), manganese (Mn) and boron (B) (Jarrel-Ash 1.5 meter spark emission spectrometer).

C. Soil Character Measurements

All O horizon soil samples were collected using a 4-inch core borer. A bucket auger (4 inch) was used for samples of the A horizon, and for texture and color at 24 and 36 inches.

1. Soil Moisture

Soil moisture was recorded under one tree in each plot from May through August. Gypsum moisture blocks and a Bouyoucos moisture meter were used.

2. Soil Temperature

Soil temperature was recorded from May through August with a Palmer thermometer in each plot.

3. Soil Texture

The percent of sand, silt and clay was determined with hydrometer readings at 40 seconds (for sand) and 8 hours.

4. Soil pH

Soil pH of the O horizon was taken with a Beckman pH meter in each plot at the location where other soil data were collected.

5. Soil Nutrients

Available P, K and N was determined for the O horizon using a LaMotte soil test kit.

6. Soil Color

The color of each soil horizon in each plot was compared with Munsell soil color charts.

RESULTS

A. Tree Measurements

1. Defoliation causes a significant reduction in terminal growth. The expected growth can be estimated by the formula:

$$Y = 0.1145(X_1) - 0.39938(X_2) + 21.67638$$

Where: Y = Expected growth (cm)
X_1 = Total tree height (cm)
X_2 = Percent defoliation

2. The amount of defoliation also affects the volume size of buds in an inverse relationship.

Defoliation Class		Bud Volume (mm^3)
Heavy (50-100%)	majority buds are	100-500
Moderate (20-49%)	majority buds are	200-800
Light (6-19%)	majority buds are	1000 and larger

Buds in the light defoliation areas flushed earlier than those of trees in areas of heavier defoliation. As defoliation increases the bud flush in the upper 1/3 of the crown is delayed, but defoliation appears to have little effect on the time of bud flushing on the lowest 1/3 of the crown. The mid third is affected but the delay is not as pronounced as in the top third.

3. Foliage Growth

The angle of distention of new needles to the central axis of the bud did not differ significantly between defoliation classes.

4. Foliage Nutrients

An equation was derived which states that heavily defoliated trees have more Mg and K and less Mn than lightly defoliation trees.

$$0.12196X_3 + 1.10838X_5 - 0.00039X_7 = Y$$

Where: $Y > 0.3316$ classify as heavily defoliated
$Y < 0.3316$ classify as lightly defoliated
X_3 = percent foliar K
X_5 = percent foliar Mg
X_7 = ppm foliar Mn

The other nutrients tested which were not found to have a significant effect on defoliation.

B. Soil Character Measurements

1. Soil moisture was greater within heavily defoliated areas than in lightly defoliated areas. The range in August, following a drought period in July, showed 23 to 35% more available soil moisture in heavily defoliated areas than in lightly defoliated areas.

2. Soil temperatures were generally higher in heavily defoliated areas than where defoliation was light.

3. Soil texture was finer in areas of heavy defoliation in the A and B horizon than in lightly defoliated areas. Soils in heavily defoliated areas had more silt and clay but less sand than the lesser defoliated areas.

4. Soil pH was not significantly different between areas of defoliation.

5. Soil nutrient analysis showed that there was two to three times less available nitrogen in heavily defoliated areas than was availabe in lightly defoliated areas. P and K were not significantly different between areas of defoliation levels.

6. Soil color was not found to have any significant influence on sawfly activity.

Of all the soil characteristics measured, four are significant and can be combined in the model equation to predict the potential level of defoliation.

$$K = -0.03481(X_1)+0.01766(X_2)-0.06598(X_3)+0.1328(X_4)$$

When: $K < 0.4977$ classify area for potential high defoliation
$K > 0.4977$ classify area for potential light defoliation

K = Potential defoliation level
X_1 = Percent clay at the 12 inch depth
X_2 = Percent sand at the 24 inch depth
X_3 = Depth of B2 + B3 horizon (inch)
X_4 = Pounds of nitrogen in the tree rooting zone

DISCUSSION

The growth of buds and foliage is influenced by a combination of previous levels of defoliation and certain soil conditions. Defoliation is most severe on soil with high available moisture, high temperature, fine soil texture and low fertility. These factors combined with the bud volume range of 200-500 mm^3, found in areas of medium to heavy prior defoliation, tend to encourage the continuance of sawfly populations within the same areas. Soil characters such as dry, cool, coarser texture and high fertility

combined with the larger bud volumes over 500 mm^3 (light to moderate previous defoliation) are less favorable for sawfly oviposition and population development.

Delayed bud flushing, caused by prior years' defoliation, may also cause the buds to be less favorable for oviposition.

Soil fertility is expressed in the foliar analysis. Areas with low nitrogen are more severely affected.

CONCLUSION

The results show that planting white spruce on soil of coarse texture (high complement of sand) and good fertility would be a major step in modifying sawfly infestations and their impact on growth rate and tree mortality.

Conversely, sites or pockets with finer textured soil and low fertility should be avoided when possible to minimize potential yellowheaded spruce sawfly damage.